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Analysis of Shisha Smoking Effect on Haematological Indices in Adult Smokers

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ABSTRACT

Shisha smoking is a rising trend among youth as a symbol of modernization and fashion. There is misconception that shisha smoking is less harmful than cigarette due to filtering effect of the liquid used in the device. The present study was conducted to investigate the effect of Shisha Smoking on haematological indices, body mass index, and lung capacity of shisha smokers. Forty shisha smokers (case group) and 40 non-smokers (control) of age ranging 17-30 years were recruited in this study with their consent. Peripheral blood samples of case and control subjects were analysed to evaluate the effect of shisha smoking on blood pressure, BMI (body mass index) and blood parameters, namely HB (hemoglobin), RBCs (red blood cells), WBCs (White blood cells), PLTs (platelets), MCV (mean corpuscular volume), MCH (mean corpuscular hemoglobin), MCHC (mean corpuscular hemoglobin), MPV (mean platelets volume) RDWc (red cell distribution width), PDWc (platelets distribution width) and MON (monocyte absolute). Our results showed elevated levels of Hb, RBCs, WBCs, PLTs, MPV, MCV and MCH with all P= 0.000 in case subjects. Significant increases in concentrations of MCHC, RDWc, PDWc and count with P=0.000 were observed in case subjects as compared to control subjects. Increased blood pressure (P=0.000), increased BMI (P=0.048) and decreased lung capacity (P=0.000) was studied in shisha smokers. Shisha smoking significantly increase the haematological indices, body mass index, systolic and diastolic blood pressure and reduces lung capacity.

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Authors' Contribution
MM conceived the idea, supervised the study and wrote the manuscript. MHN performed the experimental work. MT helped in collection of samples and literature review. PCT performed all the statistical tests.

Key words
Haemoglobin, RBCs, WBCs, BMI, Blood Pressure, Lung capacity

INTRODUCTION

Shisha smoking is the most well-known technique for inhaling tobacco among youth for the last 20 years (Zyoud *et al*., 2014). Shisha smoking is a rising trend all over the world with different names like "sheesha", "water pipe", "hubble bubble", "hookah" and "narghile" (Dar-Odeh *et al*., 2009). Recently, shisha is very popular among students of universities, colleges and schools for the pleasant and relaxing experience. It is also catching attraction of becoming more popular among women as a sign of fashion and modernization (Neergaard *et al*., 2007). It has developed as a social event among the people who gather at parties, cafes and restaurants to smoke (Mugyenyi *et al*., 2018).

The shisha device usually has a head chimney to carry flavoured tobacco covered by aluminium paper with small pieces of coal over it. It is then connected via airtight pipe to water or some other flavoured liquid bowl normally called the base. The smoke is generated with a wet-flavoured and sweetened tobacco which is heated by a small piece of coal (Primack *et al*., 2016; World Health Organization. Fact sheet: waterpipe tobacco smoking and health. Available from: http://apps.who.int/iris/bitstream/handle/10665/179523/WHO_NM H_PND_15.4_eng.pdf? [online] 2015. The mouthpiece of the pipe is shared among many people in a party or gathering and hence facilitates the transmission of communicable diseases such as tuberculosis (Akl *et al*., 2010).

It is documented that flavoured shisha tobacco contains esters, ethyl acetoacetate propylene glycol, oxygenated monoterpene, carvone, alcohols, aldehydes, and alkaloids. Shisha tobacco products come in a variety of flavours including chocolate, mint, apple, cherry, coconut, cappuccino, watermelon, and liquorice (Farag *et al*., 2018). Tobacco used in shisha smoking usually weighs 10 to 20 g and incorporates 70% honey or molasses/sugar (Fakhri *et al*., 2015).

According to the Adult Tobacco Survey in 2014, there are 3.7 million shisha smokers in Pakistan (World Health Organization. Pakistan Tobacco Free Initiative [online] 2018. Available from: http://www.emro.who.int/pak/programmes/tobacco-free-initiative.html). Further, the survey describes that 13.3% boys and 6.6% girls are tobacco users in Pakistan. A generally held notion is that shisha smoking is much less harmful than cigarette smoking

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due to filtering effect of water (El-Zaatari *et al*., 2015). But there are numerous reports which have established that shisha smoking is several-fold more dangerous than smoking cigarettes. Shisha smoke can contain lethal toxins such as nicotine, aromatic hydrocarbons, volatile aldehydes and carbon monoxide (Maziak, 2013). Shisha smoking has prompted the danger of infectious and many other diseases like cardiovascular complications, pneumonic/ bronchitis diseases, tumours and low foetal birth weight in pregnant women (Jawad *et al*., 2014).

Although shisha smoking has been the source of many lethal diseases; there are very few studies which analyse its effect on various blood markers. Miri-Moghaddam *et al*. (2014) have studied the effect of shisha smoking on wistar rats. According to their study, RBC count, HB and HCT are significantly higher in shisha smoking rats than the control group ($P < 0.001$). RBC count did not increase significantly ($P= 0.39$) while platelet count did not decrease significantly ($P= 0.13$) as compared to control rats. Similarly, in humans, platelet count is noted to increase in adolescents who start smoking relatively at an early age (El-Zaatari *et al*., 2015).

In the present study, we have investigated the effect of shisha smoking on various haematological indices/ parameters, blood pressure (BP), lung capacity and body mass index (BMI) of young people. There are very few studies showing the effect of shisha smoking on haematological parameters. It is the first study, as per authors' knowledge, which describes a complete profile of blood markers of shisha smokers and non-smokers.

MATERIALS AND METHODS

The study was approved by the ethical committee of the University of Education, Lahore. Informed written consent was taken from the participants. The control and case subjects were recruited from various localities (Iqbal Town. Sabzazar, Johar Town, DHA and Gulberg) of Lahore. The study included 40 male shisha smokers (n= 40) who had been smoking shisha for at least one year or more. They were regularly consuming one to two shisha hagar per day. The ages of case subjects ranged from 17-30 years. Forty age-matched control male subjects who were not consuming shisha/cigarette were also included in the study. Fresh peripheral blood samples (5 ml) from these shisha smokers and non-smokers were analysed for various blood parameters, specifically red blood cells (RBC), haemoglobin (HB), mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV), haematocrit (HCT), mean corpuscular haemoglobin concentration (MCHC), mean platelet volume (MPV), platelet count (PLT), red blood cell distribution width (RDWc), platelet distribution width (PDWc) and monocytes absolute (MON) by using a fully automatic haematological analyser (Sysmex KX-21N haematological analyser). In addition, lung capacity, blood pressure (BP) and body mass index (BMI) were also measured. BP was measured 10 minutes before and 10 minutes after smoking shisha in the evening times by a manual sphygmomanometer and BMI was measured by weight/height^2 (kg/m^2) in both case and control subjects.

Inclusion criteria

Participants having any type of disease during investigation and smoke both cigarettes and shisha were excluded from the study.

Data analysis

The statistical package R (version 3.4.2) was used to analyse the data (R Core Team, 2017). Continuous variables were summarized as means ± SD, median and range, with formal comparisons made using two-sample t-tests. The distribution of haematological parameters was elaborated by boxplot.

RESULTS

Table I shows baseline characteristics of case (n= 40) and control (n= 40) subjects. The majority of the subjects of both groups were students of schools, colleges and universities. Based on their reported medical histories, it was found that shisha smokers had more problems such as allergy and hypertension compared with the control group. To elucidate the results mean values are used for comparison between control and case group. These values are used as an average for quantitative data when the data is free from extreme values. The systolic blood pressure of shisha smokers before and after smoking was relatively higher than control group. Similarly, the diastolic blood pressure of shisha smokers before and after smoking was higher than control subjects (P=0.000). The lung capacity of case group was significantly lower (14.75±4.32, p=0.000) than control subjects (20.7±5.38), respectively. No significant difference between education status of case and control subjects was observed.

Table II shows the effect of shisha smoking on various haematological parameters like RBC, HB, MCH, MCV, MPV, HCT, MCHC, PLT, RDWc, PDWc and MON. For each parameters there were highly significant differences between case and control subjects (all P= 0.000), indicating that the above mentioned blood parameters are substantially affected by shisha smoking.

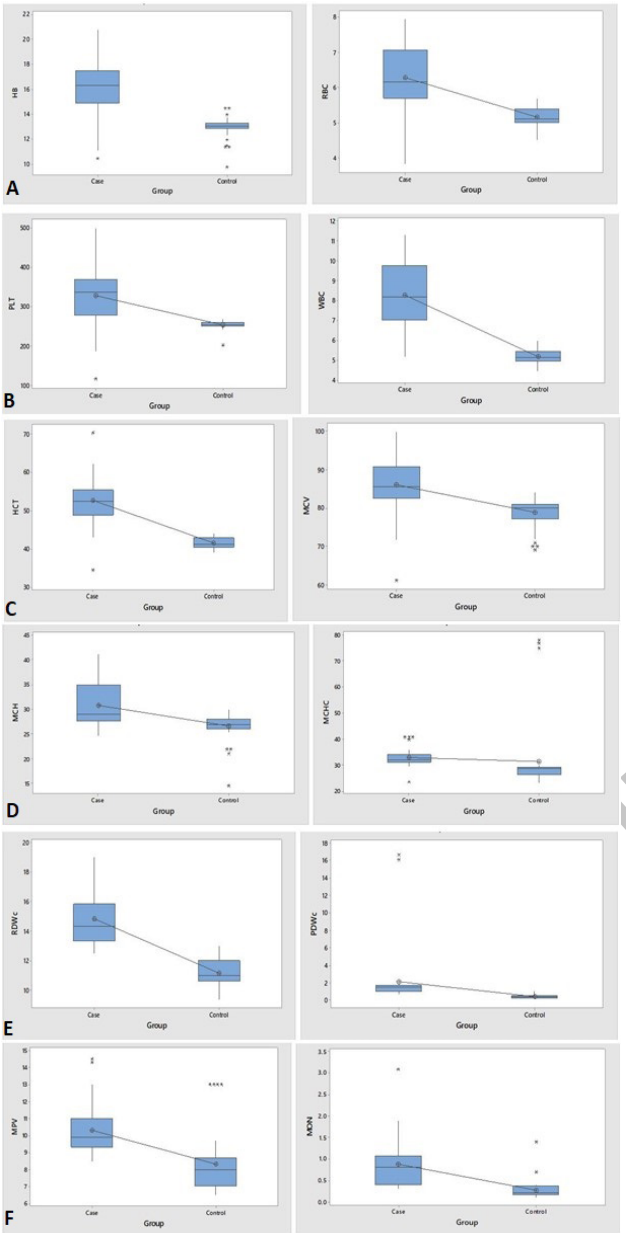

Fig. 1. Boxplot showing distribution of HB and RBCs (A), PLT and WBC (B), HCT and MCV (C), MCH and NCHC (D), RDWC and PDWC (E) and MPV and MON (F) of case and control group. A boxplot shows 5 values in addition to mean value in the center of the box (that has been shown with a dot). Among five values, it covers minimum and maximum values along with box in the middle which contains lower quartile (Q1), Median and upper quartile (Q3). Asterisk in the boxplot indicates extreme lowest/highest values. In terms of variation, case group contains higher variation within respective values as compared to control group.

Table I. Base line characteristics of control and shisha smoking subjects.

Variable	Control	Shisha smokers
Males	40	40
Age (Years), mean ±S.D	24.30 ±2.79	24.25±2.99 *p*=0.938
BMI (kg/m^2), mean ±S.D	24.36±1.43	25.19±2.61 *p*=0.048
Education status		
None	4	5
Primary	5	9
Secondary	10	8
College	15	10
University	6	8
Medical history (%)		
Arthritis	0	0
Allergy	2	7
Hypertension	1	7
Asthma	0	0
Any Infection	0	0
Drug history (%)		
Anti-inflammatory drugs	2	4
Antibiotics	3	1
Analgesics	1	2
Supplements	3	5
Blood pressure		
Systolic pressure before smoking	123.25±2.45	127.63±5.79 *p*=0.000
Systolic pressure after smoking	----	137.85±7.45
Diastolic pressure before smoking	75.21±2.11	75.35±6.56 *p*=0.000
Diastolic pressure after smoking	----	89.14±10.56
Lung capacity	20.7±5.38	14.75±4.32 *p*=0.000

Table II shows the average level of HB of case subjects (13.06) was lower than the level in control subjects (16.44). The difference in means of case and control of HB was highly significant based on a two-sample *t*-test (*P*= 000). There is significant difference between median values of PLTs in case (336 x 10^9/l) and control subjects

(253.06 x 10^9/l). Similar difference can be observed between the WBC count of case and control subjects. More over our data show the maximum value of PLTs in case subjects was 499 × 10^9/l which was abnormally higher than the control subjects value (268 × 10^9/l). The difference in means of PLTs and WBC count of case and control subjects was highly significant based on a two-sample t-test (*P*=000). Similarly, the median value of HCT in case and control subjects was 52.30 % and 41.15%, respectively. Furthermore, the difference in means of HCT and MCV of case and control was highly significant (*P*=000). There is significant difference between maximum MCH value of case (41.2 pg) and control group (30.0 pg). The mean of MCH and MCHC was significantly different in case and control groups based on *t*-test (p=000). The analysis of blood parameters shows that median value of RDWc of case and control subjects was 14.3 % and 11% respectively. The difference in averages of RDWc and PDWc of case and control was highly significant (*P*=000). Moreover, the median value of MPV of case subjects was 9.9 fl as compared to 8 fl in control. Similar difference was observed between MON values of case (0.79×10^9/l) and control subjects (0.2×10^9/l). The mean values of both parameters were significantly different in both groups based on *t*-test (*p*=000).

Table II. Effect of shisha smoking on haematological parameters of case and control group.

Parameters	Control group (*n*=40) Mean + SD	Case group (*n*=40) Mean + SD	*P* = 0.05
HB (g/dl)	16.44±1.971	13.06±0.667	0.000
MPV (fl)	8.3080±1.7860	10.303±1.4190	0.000
WBCs (x 10^9/l)	5.1780±0.3140	8.2890 ±1.6340	0.000
PLTs (x 10^9/l)	253.18±10.320	327.10±78.500	0.000
MCV (fl)	78.799±3.7440	86.070±6.7100	0.000
HCT (%)	41.521±1.2690	52.630±6.2170	0.000
RBCs (x 10^{12}/l)	5.161±0.2440	6.284±0.8970	0.000
MCH (pg)	26.607±2.7380	30.796±4.1410	0.000
MCHC (g/dl)	27.5575±1.8676	32.704±3.4690	0.000
RDWc (%)	11.142±0.8160	14.830±1.8590	0.000
PDWc (x 10^9/l)	0.3950±0.2242	1.3742±.376	0.000
MO abs (x 10^9/l)	0.2750±0.220	0.8772±0.579	0.000

DISCUSSION

The present study investigates the effect of shisha smoking on blood pressure, lung capacity, BMI and haematological parameters of young individuals. The BMI of shisha smokers was higher than the non-smokers (p= 0.048). The systolic and diastolic blood pressure of case subjects was significantly higher before the shisha smoking than the control subjects. Similarly, the systolic and diastolic blood pressure of case subjects after shisha smoking was significantly higher before smoking shisha. All the blood indices (HB, RBCs, PLT, WBC, MCV, HCT, MCH, MCHC, RDWc, PDWc, MPV and MON) were significantly affected by shisha smoking when compared with control group based on *t*-test (*p*= 000).

Our results showed that there was significant increase in mean of HB, RBCs, HCT, WBCs, MCV based on t-test (*p*= 000) of case as compared to control subjects. Similar findings were reported by Malenica *et al*. (2017) where significantly higher levels of WBC count (p<0.001), RBCs (p<0.001), HCT (p= 0.047) and HB (p= 0.042) were observed in smokers compared with non-smokers. There are several reports which support our results that shisha smoking raises the levels of haematological parameters as compared to non-smokers (Pankaj *et al*., 2014; Nadia *et al*., 2015; Lakshmi *et al*., 2014). Increased level of haemoglobin and haematocrit are linked with increased size and number of RBCs. It is reported that water pipe smoking (which is simple form of shisha smoking) elevated the levels of carboxyhaemoglobin significantly after smoking (1.47% ± 0.57% to 9.47% ± 5.52%). Carbon monoxide (CO) has a higher affinity for haemoglobin than oxygen and resultantly it displaces oxygen from RBCs and hence oxygen supply to the tissues decreases (Cronenberger *et al*., 2008). Nicotine in combination with CO disrupts the oxygen supply to the body tissues which stimulates bone marrow to generate more RBCs and subsequently increases HGB and HCT (Roethig *et al*., 2010). These conditions may contribute to the incidence of atherosclerosis and other cardiovascular complications (Law and Wald, 2003). There are certain studies which describe the elevated level of RBCs and haemoglobin as a compensatory mechanism against carboxyhaemoglobin to make up the reduced level of oxygen in the body tissues (Robinson *et al*., 2018). However, there are certain findings which are not in agreement with our results in which some blood parameters (RBCs, WBCs and PLT etc.) were not affected significantly due to smoking (Shah *et al*., 2012).

Our findings showed significant elevation in MCHC and MCV in shisha smokers compared with non-smokers. This finding is consistent with the report by Malenica *et al*. (2017) in which MCV (p=0,001) and MCHC (p<0,001) were significantly increased in cigarette smokers. The higher levels of MCV and MCHC were confirmed by other studies (Khan *et al*., 2014; Kung *et al*., 2008). However, Pankaj *et al*. (2014) could not detect any

significant difference in MCH and MCHC of smokers and non-smokers. Some studies are in contrast to our results where MCV and MCHC levels are significantly lower ($p<0.05$) in smokers than in non-smokers (Salamzadeh, 2004). The present study shows increased levels of PCV and HB in shisha smokers when compared with control. Our findings are supported by Lakshmi *et al*. (2014) who showed that HB (P=0.05) and PCV (P=0.005) levels were extraordinarily increased in cigarette smokers and this level even increased with increasing duration of smoking.

Our findings showed elevated levels of WBC (P=000) and PLT (P=000) in shisha smokers than the non-smokers. These results are supported by earlier studies where increased levels of WBC and PLT were found (Inal *et al*., 2014; Higuchi *et al*., 2016). There is a positive link between shisha smoking and white blood cells, thrombocytes, and red blood cell indices (Milman *et al*., 2009). Increased white blood (leukocytes) cells and PLT due to smoking may be explained by a systemic inflammatory response (Inal *et al*., 2014). These results were in line with Nadia *et al*. (2015) who showed that elevated platelet count in shisha smokers was due to fibrinogen linked receptors of platelets, which increase the hypo coagulate state and damage and disorganize the endothelial lining of cells. A strong correlation was reported between smoking and atherosclerosis and cardiovascular diseases. The potential damage caused by smoking entails an enhancement in WBC count, PLT reactivity, change in lipids and lipoprotein levels and homeostasis system (Al-Awadhi *et al*., 2008). Some studies showed that an increase in WBC count might be due to nicotine-induced release of catecholamines and steroid hormones (Deutsch *et al*., 2007). Shisha smoking causes allergic inflammation on the respiratory tree due to which WBC count increases significantly (Calapai *et al*., 2009). Further, with an increase in period of shisha smoking, WBC counts increased when compared to light smokers and chain shisha smokers. Our findings are similar to that of Kurtoglu *et al*. (2013), and Miri-Moghadam *et al*. (2014), who reported similar results about WBC counts in smokers.

Our findings showed significantly higher BMI of shisha smokers than non-smokers. The increase in WBC count and BMI in smokers has a positive relationship. Increased BMI is linked to serum protein called C-reactive protein (CRP), which also affects the WBC count both in male and females (Nakanishi *et al*., 2002).

MCV, MCH, and MCHC are three main red blood cell parameters that help in measuring the average size and haemoglobin composition of the RBC. Our study demonstrated significantly larger values of MCV and MCHC among shisha smokers. Larger values of MCV, MCH, and MCHC in shisha smokers were also confirmed by Khan *et al*. (2014). An increase in these parameters causes many disorders such as kidney dysfunction, hypertension, and hypercholesterolemia in smokers (Kung *et al*., 2008).

CONCLUSION

This investigation shows very visible and clinically significant information on the effect of shisha smoking on heart rate, systolic and diastolic blood pressure, haematocrit, erythrocyte count, leukocyte count and haemoglobin level. These altered blood indices may lead to other clinical conditions such as lung malignancies, atherosclerosis and cardiovascular diseases.

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Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Akl, E.A., Gaddam, S., Gunukula, S.K., Honeine, R. and Jaoude, P.A., 2010. The effects of waterpipe tobacco smoking on health outcomes: A systematic review. *Int. J. Epidemiol.*, **39**: 834-857. https://doi.org/10.1093/ije/dyq002

Al-Awadhi, A.M., AlFadhli, S.M. and Mustafa, N.Y., 2008. Effects of cigarette smoking on haematological parameters and von Willebrand factor functional activity levels in asymptomatic male and female Arab smokers. *Med. Princ. Pract.*, **17**: 149-153. https://doi.org/10.1159/000112970

Calapai, G., Caputi, A.P. and Mannucci, C., 2009. Cardiovascular biomarkers in groups of established smokers after a decade of smoking. *Basic clin. Pharmacol. Toxicol.,* **104**: 322–328. https://doi.org/10.1111/j.1742-7843.2008.00361.x

Cronenberger, C., Mould, D.R. and Roethig, H.J., 2008. Population pharmacokinetic analysis of carboxyhaemoglobin concentrations in adult cigarette smokers. *Br. J. clin. Pharmacol.,* **65**: 30-39. https://doi.org/10.1111/j.1365-2125.2007.02974.x

Dar-Odeh, N.S. and Abu-Hammad, O.A., 2009. Narghile smoking and its adverse health consequences: A literature review. *Br. Dent. J.*, **206**: 571-573. https://doi.org/10.1038/sj.bdj.2009.475

Deutsch, V., Lerner-Geva, L., Reches, A., Boyko, V., Limor, R. and Grisaru. D., 2007. Sustained leukocyte count during rising cortisol level. *Acta. Haematol.*, **118**: 73-76.

El-Zaatari, Z.M., Chami, H.A. and Zaatari, G.S., 2015. Health effects associated with waterpipe smoking. *Tobacco Contr.,* **24**: i31-i43. https://doi.org/10.1136/tobaccocontrol-2014-051908

Fakhari, A., Mohammad, P.A., Nedjat, S., Sharif, H.M. and Fotouhi, A., 2015. Hookah smoking in high school students and its determinants in Iran: A longitudinal study. *Am. J. Men's Hlth.*, **9**: 186-192. https://doi.org/10.1177/1557988314535236

Farag, M.A., Elmassry, M.M. and El-Ahmady, S.H., 2018. The characterization of flavoured hookahs aroma profile and in response to heating as analysed via headspace solid-phase microextraction (SPME) and chemometrics. *Sci. Rep.,* **8**: 17028-17032. https://doi.org/10.1038/s41598-018-35368-6

Higuchi, T., Omata, F., Tsuchihashi, K., Higashioka, K., Koyamada, R. and Okada, S., 2016. Current cigarette smoking is a reversible cause of elevated white blood cell count: Cross-sectional and longitudinal studies. *Prev. Med. Rep.,* **4**: 417-422. https://doi.org/10.1016/j.pmedr.2016.08.009

Inal, B., Hacibekiroglu, T., Cavus, B., Musaoglu, Z., Demir, H. and Karadag, B., 2014. Effects of smoking on healthy young men's hematologic parameters. *North Clin. Istanb.,* **1**: 19-25.

Jawad, M., Lee, J.T. and Millett, C., 2014. The relationship between waterpipe and cigarette smoking in low and middle income countries: Cross-sectional analysis of the global adult tobacco survey. *PLoS One*, **9**: e93097. https://doi.org/10.1371/journal.pone.0093097

Khan, M.I., Bukhari, M.H., Akhtar, M.S. and Brar, S., 2014. Effect of smoking on red blood cells count, hemoglobin concentration and red cell indices. *Pak. J. Med. Hlth. Sci*., **8**: 361-364.

Kung, C.M., Wang, H.L. and Tseng, Z.L., 2008. Cigarette smoking exacerbates health problems in young men. *Clin. Invest. Med.,* **31**: E138-149. https://doi.org/10.25011/cim.v31i3.3471

Kurtoğlu, E., Aktürk, E.E., Korkmaz, H., Sincer, I., Yılmaz, M., Erdem, K., Çelik, A. and Özdemir, R., 2013. Elevated red blood cell distribution width in healthy smokers. *Arch. Turk Soc. Cardiol.,* **41**:199-206.

Lakshmi, A.A., Lakshmanan, G.P. and Saravanan, A., 2014. Effect of intensity of cigarette smoking on haematological and lipid parameters. *J. clin. Diag. Res.,* **8**: BC11-13. https://doi.org/10.7860/JCDR/2014/9545.4612

Law, M.R. and Wald, N.J., 2003. Environmental tobacco smoke and ischemic heart disease. *Prog. Cardiovasc. Dis.,* **46**:31–38. https://doi.org/10.1016/S0033-0620(03)00078-1

Malenica, M., Prnjavorac, B. and Bego, T., 2017. Effect of cigarette smoking on haematological parameters in healthy population. *Med. Arch.,* **71**: 132-136. https://doi.org/10.5455/medarh.2017.71.132-136

Maziak, W., 2013. The waterpipe: An emerging global risk for cancer. *Cancer Epidemiol.,* **37**: 1-4. https://doi.org/10.1016/j.canep.2012.10.013

Milman, N. and Pedersen. A.N., 2009. Blood haemoglobin concentrations are higher in smokers and heavy alcohol consumers than in non-smokers and abstainers: Should we adjust the reference range? *Ann. Hematol.,* **88**: 687–694.

Miri-Moghaddam, E., Mirzaei, R., Arab, M.R. and Kaikha, S., 2014. The effects of water pipe smoking on hematological parameters in rats. *Int. J. Hemat. Oncol. Stem Cell Res.,* **8**: 37-41.

Mugyenyi, A.E., Haberer, J.E. and O'Neil, I., 2018. Pleasure and practice: A qualitative study of the individual and social underpinnings of shisha use in cafes among youth in the UK. *BMJ Open*., **8**: e018989. https://doi.org/10.1136/bmjopen-2017-018989

Nadia, M.M., Shamseldein, HA. and Sara, A.S., 2015. Effects of cigarette and shisha on hematological parameters: An analytic case-control study. *Int. Multispec. J. Hlth*., **1**: 44-51.

Nakanishi, N., Sato, M.S., Shirai, K.S., Suzuki, K.S. and Kozo, T., 2002. White blood cell count as a risk factor for hypertension; a study of Japanese male office workers. *J Hypertens.*, **20**: 851-857. https://doi.org/10.1097/00004872-200205000-00018

Neergaard, J., Singh, P., Job, J. and Montgomery. S., 2007. Waterpipe smoking and nicotine exposure: A review of the current evidence. *Nicotine Tob. Res.,* **9**: 987-994.

Özdemir, R., 2013. Elevated red blood cell distribution width in healthy smokers. *Arch. Turk. Soc. Cardiol.,* **41**: 199-206. https://doi.org/10.5543/tkda.2013.42375

Pankaj, J., Reena, J., Mal, K.L. and Ketan, M., 2014. Effect of cigarette smoking on haematological parameters: Comparison between male smokers and non-smokers. *Int. J. Secur. Netw.*, **5**: 740-743.

Robinson, R.J., Hensel, E.C., Al-Olayan, A.A., Nonnemaker, J.M. and Lee, Y.O., 2018. Effect of e-liquid flavour on electronic cigarette topography and consumption behavior in a 2-week natural

environment switching study. *PLoS One,* **3**: e0196640. https://doi.org/10.1371/journal.pone.0196640

Primack, B.A., Carroll, M.V., Weiss, P.M., Shihadeh, A.L., Shensa, A., Farley, S.T. and Nayak, S., 2016. Systematic review and meta-analysis of inhaled toxicants from waterpipe and cigarette smoking. *Pub. Hlth. Rep.,* **131**: 76-85.

R. Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. https ://www.R-project.org

Roethig, H.J., Koval, T. and Muhammad-Kah, R., 2010. Short term effects of reduced exposure to cigarette smoke on white blood cells, platelets and red blood cells in adult cigarette smokers. *Regul. Toxicol. Pharmacol*., **57**: 333-337. https://doi.org/10.1016/j.yrtph.2010.04.005

Salamzadeh, J., 2004. The hematologic effects of cigarette smoking in healthy men volunteers. *Iran J. Pharm. Res.,* **3**: 41-44.

Shah, B.K., Nepal, A.K., Agrawal, M. and Sinha, A.K., 2012. The effects of cigarette smoking on hemoglobin levels compared between smokers and non-smokers. *Sunsari Tech. Coll. J.,* **1**: 42-44. https://doi.org/10.3126/stcj.v1i1.7985

World Health Organization (WHO), 2015. Fact sheet: Water pipe tobacco smoking and health. http://apps.who.int/iris/bitstream/handle/10665/179523/WHO_NM H_PND_15.4_eng.pdf? Accessed August 24, 2020.

World Health Organization (WHO), 2018. Pakistan tobacco free initiative [online]. http://www.emro.who.int/pak/programmes/tobacco-free-initiative.html Accessed August 24, 2020.

Zyoud, S.E.H., Al-Jabi, S.W. and Sweileh, W.M., 2014. Bibliometric analysis of scientific publications on waterpipe (narghile, shisha, hookah) tobacco smoking during the period 2003-2012. *Tob. Induc. Dis*., **12**: 1-6. https://doi.org/10.1186/1617-9625-12-7